Stromingsleer – antwoorden tentamen 28 juni 2011

uitwerking MC

1. schokgolf: $Ma_1 > Ma_2$, $\rho_1 < \rho_2$ $\Rightarrow$ B

2. $p_2 \ll p_1$ $p_3 < p_1$ (kleine verliezen) $\Rightarrow$ D

3. drukverschil manometer: $\Delta p = (\rho_{Hg} - \rho_{olie}) \cdot g \cdot h = (13550-870) \cdot 9{,}81 \cdot 0{,}42$
$= 52{,}2$ kPa $\Rightarrow h_f = \dfrac{\Delta p}{\rho g} = 6{,}12$ m

drukverlies door straming
$h_f = 6{,}12 - 3 = 3{,}12$ m $\quad \Delta p = \rho g h_f = 26{,}6$ kPa

$$Q = \frac{\Delta p \cdot \pi D^4}{128 \mu L} = \frac{26{,}6 \cdot 10^3 \cdot \pi \cdot (0{,}04)^4}{128 \cdot 0{,}104 \cdot 3} = 0{,}005536 \ \frac{m^3}{s} \hat{=} 19{,}3 \ m^3/h$$
B

4. $Q = \dot{m}/\rho = 25/1000 = 0{,}025 \ m^3/s \qquad V = \dfrac{Q}{\frac{\pi}{4}D^2} = \dfrac{0{,}025}{\frac{\pi}{4}(0{,}05)^2} = 12{,}7$ m/s

$$F_x = (p_1 - p_a) \cdot \tfrac{\pi}{4} D^2 + (p_2 - p_a) \tfrac{\pi}{4} D^2 + \dot{m}(-V - V)$$
$$= (65{,}000 + 34{,}000) \cdot \tfrac{\pi}{4} (0{,}05)^2 + 25 \cdot 2 \times 12{,}7$$
$$= 831 \text{ N.}$$
C

5. $[kg/m^3]^a [m/s^2]^b [m]^c [kg/m \cdot s]^d \Rightarrow \begin{cases} kg: & a + d = 0 \\ m: & -3a + b + c - d = 0 \\ s: & -2b - d = 0 \end{cases}$

gegeven $d = -2 \Rightarrow \begin{cases} a = 2 \\ b = 1 \\ c = 3 \end{cases} \Rightarrow Ga = \dfrac{\rho^2 g L^3}{\mu^2}$ A

6. $C_D \sim 0{,}4 \qquad \frac{\pi}{6} D^3 \cdot \Delta\rho g = C_D \cdot \frac{\pi}{4} D^2 \cdot \frac{1}{2} \rho_l V^2 \Rightarrow V = \left(\frac{4}{3} \frac{D g \Delta\rho}{C_D \rho_l} \right)^{1/2} = 11{,}7$ m/s
$= 42$ km/u

C

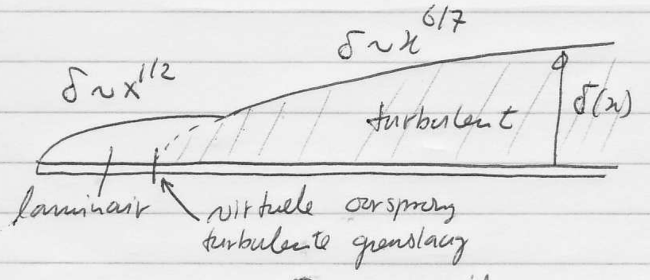
7. $dM = r dF = r \cdot \tau_w \cdot 2\pi r dr \qquad \tau_w = \mu \cdot \dfrac{\Omega r}{\theta \cdot r}$

$$M = \int_0^R \mu \frac{\Omega}{\theta} \cdot 2\pi r^2 dr = \frac{\mu \Omega}{\theta} \frac{2\pi R^3}{3} \Rightarrow \mu = \frac{3 M \theta}{2\pi \Omega R^3}$$
$$\mu = \frac{3 \cdot 0.157 \cdot 0.052}{2\pi (2\pi \cdot 600/60)(0{,}06)^3} = 0{,}287 \text{ Pa·s}$$
A

Open vraag 1

a) $U = 5\,m/s,\; L = 0{,}40\,m,\; \nu = 10^{-6}\,m^2/s \Rightarrow Re_L = \dfrac{5\times 0{,}40}{10^{-6}} = 2\times10^{6}$

b)



c) $Re_{trans} = 5\times10^{5} = \dfrac{x_{trans}\,U}{\nu} \Rightarrow x_{trans} = \dfrac{5\times10^{5}\cdot10^{-6}}{5} = 0{,}10\,m.$

$\dfrac{\delta}{x} = \dfrac{5{,}48}{\sqrt{5\times10^{5}}} \Rightarrow \delta = \dfrac{5{,}48\times0{,}1}{\sqrt{5\times10^{5}}} = 0{,}775\times10^{-3}\,m.$

d) $\dfrac{\delta}{x} = \dfrac{0{,}16}{Re_x^{1/7}} \Rightarrow \delta = \dfrac{x_0\cdot 0{,}16}{(Ux_0/\nu)^{1/7}} = 0{,}16\,x_0^{6/7}\left(\dfrac{\nu}{U}\right)^{1/7}$

$\Rightarrow x_0^{6/7} = \dfrac{\delta}{0{,}16}\left(\dfrac{\nu}{U}\right)^{-1/7} \Rightarrow x_0 = \left(\dfrac{\delta}{0{,}16}\right)^{7/6}\left(\dfrac{\nu}{U}\right)^{-1/6}$

$\Rightarrow x_0 = \left(\dfrac{0{,}775\times10^{-3}}{0{,}16}\right)^{7/6}\left(\dfrac{10^{-6}}{5}\right)^{-1/6} = 0{,}026\,m.$

virtuele oorsprong bevindt zich $0{,}10 - 0{,}026 = 0{,}074$ m van de voorkant van de plaat.

e)

laminair: $C_D = \dfrac{1{,}46}{\sqrt{5\times10^{5}}} = 0{,}002065$

$D = C_D\times x_t\times b\cdot\frac{1}{2}\rho U^2 = C_D\times0{,}10\times2{,}0\times\frac{1000}{2}\times5^2 = 5{,}16\,N.$

turbulent: $Re_x = \dfrac{(0{,}40-0{,}074)\cdot U}{\nu} = 1{,}63\times10^{6}$

$C_D = 0{,}031\times(1{,}87\times10^{6})^{-1/7} = 0{,}004017$

$D = C_D\cdot(0{,}40-0{,}074)\cdot2{,}0\times\frac{1000}{2}\times5^2 = 32{,}74\,N$

eerst stuk TBL (corr.): $Re_x = \dfrac{0{,}026\times5}{10^{-6}} = 1{,}30\times10^{5}$ $\quad C_D = 0{,}031\times(1{,}3\times10^{5})^{-1/7} = 0{,}005763$

$D = C_D\cdot0{,}026\times2\times\frac{1000}{2}\times5^2 = 3{,}75\,N$

totale drag $2\times(5{,}16+32{,}74-3{,}75) = \underline{68{,}3\,N}$

Open vraag 2

a) $\frac{1}{2}\Phi = u\cdot h\cdot b \Rightarrow u = \frac{\Phi}{2hb}$ $Re = \frac{u\cdot h}{\mu/\rho} = \frac{\rho\Phi\cdot\cancel{h}}{2\mu b\cancel{h}}$

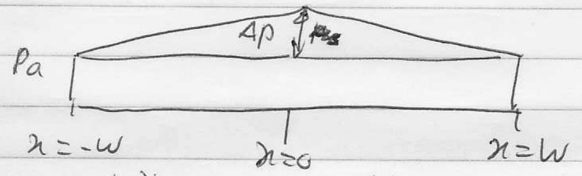
$\frac{\rho\Phi}{b} = 2\cdot Re\cdot\mu = 2\cdot 2000\times 0,1 = \boxed{400\ \frac{kg}{m\cdot s}}$

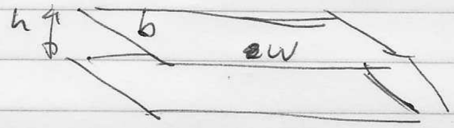
b) $V(y) = G\cdot y(h-y)$ $\frac{1}{2}\Phi = b\int_0^h V(y)dy = bG\int_0^h (yh-y^2)dy$

$= bG\left[\frac{1}{2}hy^2 - \frac{1}{3}y^3\right]_0^h = b\cdot G\cdot\frac{1}{6}h^3$

$\frac{1}{2}\Phi = b\cdot G\cdot\frac{1}{6}h^3 \Rightarrow G = \frac{1}{2}\Phi\cdot\frac{6}{bh^3} = \frac{3\Phi}{bh^3}$

c)





$\Delta p\cdot h\cdot\cancel{b} = \tau_w\cdot 2\cdot\cancel{b}\cdot w \Rightarrow \Delta p = \frac{2w}{h}\cdot\tau_w$

$\tau_w = \mu\frac{dV}{dy}\Big|_{y=0} = \frac{3\Phi\mu}{bh^3}\cdot(h-2y)\Big|_{y=0} = \frac{3\Phi\mu}{bh^2}$

$\Rightarrow \Delta p = \frac{2w}{h}\frac{3\Phi\mu}{bh^2} = \frac{6w\Phi\mu}{bh^3}$

$F = 2w\cdot b\cdot\frac{1}{2}\cdot\Delta p = \cancel{2}w\cancel{b}\frac{1}{\cancel{2}}\cdot\frac{6w\Phi\mu}{\cancel{b}h^3} = \frac{6w^2\Phi\mu}{h^3}$

$\Rightarrow \boxed{h^3 = \frac{6w^2\mu}{F}\Phi}$ $\Phi = 1\ l/min = 1,67\times10^{-5}\ m^3/s$

$h = \left(\frac{6\times(0,05)^2\cdot 0,1}{100}1,67\cdot 10^{-5}\right)^{1/3} = \underline{\underline{0,63\ mm}}$

$Re = \frac{800\cdot 1,67\times10^{-5}}{2\times 0,1\cdot 1} = 0,0668$ OK.